Effects of moving ice on banks, river bars and rock outcrops have been described by Wentworth.[9] Eardley [10] and Williams [11] have noted that erosion of banks during the short break-up period is minor compared to the work of current and wind waves, although ice lifted over the banks by high water can sweep through forests or river settlements.

Since present observations were limited to a single locality, they must be considered valid only for the village of Beaver, though general sequences of events are probably duplicated elsewhere along the river. Future studies of break-up and freeze-up should gather many quantitative data on hydrology and meteorology of the entire river system, together with systematic observations at many points over a period of several years.

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GEOPHYSICAL DISCUSSION

"CHANGES in World Glaciation" was the subject of a discussion at a joint meeting of the Royal Astronomical Society and the British Glaciological Society held at Burlington House, London, on 29 January 1954. The principal speakers were Professor F. E. Zeuner, Institute of Archaeology, University of London; Dr. J. D. H. Wiseman, British Museum (Natural History); Professor G. Manley, Bedford College, London; and Mr. F. Hoyle, St. John's College, Cambridge. Mr. Gerald Seligman was in the chair.

Opening the meeting, Mr. Seligman called for further work on the causes of changes in world ice-cover, and referred to Dr. H. W. Ahlmann's insistence on the value of such studies in interrelating the sciences.

Professor Zeuner stressed the importance of integrating evidence in both space and time: to ignore either was to make the problem falsely simple. Thus the problem of relating glaciation to eustatic changes in the Pleistocene in areas deemed reasonably free from isostatic movements was complicated by the fact that, apart from the effects of the Ice Age, there appeared to have been an overall lowering of sea level during the past million years throughout southern and south-western Europe. If that was so, the problem of relating ice-cover to large-scale tectonic movements was far from simple. Detailed study of the Thames terraces and of beach levels had revealed rhythmical fluctuations of the order of 1800–2000 years in the prevailing post-glacial fall of sea level relative to the land. The relationship of these fluctuations to tectonic changes and to changes in the extent of ice was still open to discussion.

Dr. Wiseman gave some fascinating glimpses of results from studying core samples brought

back from the equatorial Atlantic Ocean by the Swedish Deep-Sea Expedition 1947–48, on which work was still proceeding. In suitable deep-sea cores it was possible to determine past changes in surface water temperatures by three different methods: by measuring (*a*) the contribution of calcium carbonate per cm.^{2} per year, (*b*) the species distribution of planktonic foraminifera, and (*c*) the oxygen-18 content in specific planktonic foraminifera. Determinations by these three methods agreed well. Assessment of a short pilot core showed a series of minor oscillations imposed on a major curve. Three methods have been found for making age determinations. It was of great interest that the minor oscillations in the rate of sedimentation of calcium carbonate appeared to synchronize with minor climatic oscillations in more temperate latitudes. For example, a minor oscillation at a depth of 22·4 cm. corresponded to the age 9300 B.C.: the date of the Allerød oscillation in Denmark had recently been put at 8800–9900 B.C. Dr. Erickson had made correlations between cores and had concluded that sedimentation was continuous and normal.

Professor Manley also called for further studies of changes in the extent of ice-cover. The series of curves from several countries assembled by Dr. Ahlmann showed that a marked degree of parallelism existed round the North Atlantic. It was also tempting to correlate the fluctuations of south Icelandic glaciers with what is known of fluctuations in the mean summer temperature in England. The eccentric position of the Pleistocene glaciation on either side of the North Atlantic suggested that the key to past changes might lie in studies in and around that ocean. Minor recent fluctuations in climate (of the order of two or three decades) had occurred in the presence of a warm North Atlantic. The greater phenomena of the past—and especially the Ice Age—required a much cooler ocean off north-west Europe, and, moreover, that cooling must have occurred well before the climax of the glaciation. There were reasons for thinking that each of the minor late-glacial readvances in Britain were preceded by a fall in temperature of the same order as that required for the maintenance of maximum glaciation but of much shorter duration. A rough calculation indicated that fifty to a hundred years would suffice for the post-Allerød readvance in the Lake District, which lasted for about four centuries. Thus it appeared that advance could be brought about relatively rapidly, followed by much longer periods of stagnation or slow retreat. We have to explain how it is that displacements in the world's atmospheric circulation which are now merely ephemeral could become more persistent.

Mr. Hoyle thought that the climatic change from the late-glacial to the climatic optimum was so great as to be outside the operation of the Earth's meteorological system. Astronomers were not happy about such rapid changes in solar variation. Such effects as local variations in the amount of interstellar matter between the sun and Earth were now measurable and could not be accepted as sufficient cause. Dr. E. G. Bowen's work in Australia had reopened the question. It is possible to explain the remarkable tendency for intensification of rainfall on certain days in Australia (and elsewhere) by invoking showers of meteoric dust to provide the necessary nuclei. Similarly, a possible explanation of changing climate was the break-up of a large comet providing sufficient material to interfere with the Earth's atmospheric store of water vapour on a large scale. The mean mass of comets was consistent with this suggestion, as were the size of particles providing the zodiacal light.

Mr. Hoyle's suggestions excited much comment. In reply to a question, Dr. Wiseman said that the deep-sea cores were now being examined for nickel content and they hoped soon to know whether the nickel was of cosmic origin. Replying to another speaker, Mr. Hoyle said he thought the particles might take as long as twenty days to fall through the atmosphere.

The discussion was, of its nature, inconclusive. It has been described (by Professor G. Manley in *Nature* of 26 June 1954) as " cheerfully provocative." What emerged from this unusual meeting was the need on the one hand for more exact knowledge and on the other for the larger view (not confined to one field) in seeking for causes of change.

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